

Diborane (B₂H₆)
CAS 19287-45-7; UN 1911

Synonyms include boroethane, boron hydride, diboron hexahydride.

- **Persons exposed only to diborane pose little risk of secondary contamination to personnel outside the Hot Zone.**
- **Diborane is a colorless highly flammable gas with a repulsive, sickly sweet odor. At high concentrations, it ignites spontaneously in moist air at room temperature. It reacts with water to form hydrogen and boric acid. Diborane vapors are heavier than air and may collect in low-lying areas.**
- **Diborane is highly irritant when it contacts moist tissues such as the eyes, skin, and upper respiratory tract and can cause thermal burns. Burns are caused by the exothermic reaction of hydrolysis. Ingestion of diborane is unlikely since it is a gas at ambient temperatures.**

Description

At room temperature, diborane is a colorless gas with a repulsive, sickly sweet odor. It is generally shipped in pressurized cylinders diluted with hydrogen, argon, nitrogen, or helium. It reacts with water to form hydrogen and boric acid. It mixes well with air and explosive mixtures are easily formed. At high concentrations, it will ignite spontaneously in moist air at room temperature. The main toxic effect of exposure to diborane is irritation of the respiratory airway, skin, and eyes.

Routes of Exposure*Inhalation*

Inhalation is the major route of exposure to diborane. An odor threshold between 2 and 4 ppm has been reported for diborane, which is higher than the OSHA permissible exposure limit (PEL) of 0.1 ppm. Prolonged, low-level exposures, such as those that occur in the workplace, can lead to olfactory fatigue and tolerance of diborane's irritant effects. **Odor does not provide adequate warning of hazardous concentrations.** Diborane is heavier than air; exposure to concentrations exceeding the PEL may result in skin, respiratory, and eye irritation in poorly ventilated, enclosed, or low-lying areas.

Children exposed to the same levels of diborane as adults may receive larger dose because they have a greater lung surface area:body weight ratios and higher minute volume:weight ratios. In addition, they may be exposed to higher levels than adults in the

same location because of their short stature and the higher levels of diborane found nearer to the ground.

Skin/Eye Contact

Direct contact with concentrated diborane vapors may cause severe eye or skin burns, leading to cell death and ulceration.

Ingestion

Ingestion is unlikely to occur because diborane is a gas at room temperature.

Sources/Uses

Diborane is produced by the reaction of lithium hydride with boron trifluoride catalyzed by ether at 25 °C.

Diborane is used in rocket propellants and as a reducing agent, as a rubber vulcanizer, as a catalyst for olefin polymerization, as a flame-speed accelerator, and as a doping agent in the manufacture of semiconductor devices.

Standards and Guidelines

OSHA PEL (permissible exposure limit) = 0.1 ppm

NIOSH REL (recommended exposure limit) = 0.1 ppm

NIOSH IDLH (immediately dangerous to life or health) = 15 ppm

AIHA ERPG-2 (maximum airborne concentration below which it is believed that nearly all persons could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action) = 1 ppm.

Physical Properties

Description: Colorless gas at room temperature

Warning properties: odor does not provide adequate warning of hazard

Molecular weight: 27.7 daltons

Boiling point: (760 mm Hg) = -135 °F (-92.8 °C)

Freezing point: -264.8 °F (-164.9 °C)

Specific gravity (liquid): 0.210 at 15 °C

Vapor pressure: >1 atm at 20 °C

Gas density: 0.965 (air = 1)

Water solubility: Decomposes in water

Flammability: Highly flammable, ignites spontaneously in air at 40-50 °C

Flammable Range: 0.8 % to 88 % (concentration in air)

Incompatibilities

Diborane is incompatible with oxidizers, aluminum, halogens, and water.

Health Effects

- **Diborane gas is irritating to the eyes, skin, and respiratory tract. It may cause burning of the eyes, nose, and throat; cough and constriction and edema of the airway and lungs can occur. Other possible effects include dizziness, headache, weakness, and lack of coordination. Kidney and liver damage may rarely occur.**
- **Local irritation is caused by the exothermic nature of the hydrolysis reaction.**
- **Individuals with pre-existing respiratory diseases may be more susceptible to exposure to diborane.**

Acute Exposure

The toxic effects of diborane are primarily due to its irritant properties. The local irritant action of diborane is due to the heat released as a consequence of its reaction with water and products formed by the hydrolysis reaction, such as boron oxide. Symptoms may be apparent immediately or delayed for a few hours.

Children do not always respond to chemicals in the same way that adults do. Different protocols for managing their care may be needed.

Respiratory

Exposure to diborane can cause a sensation of tightness of the chest leading to diaphragmatic pain, shortness of breath, cough, and wheezing. These signs and symptoms, which may be delayed for up to 24 hours, can be seen for 3 to 5 days after an exposure.

Children may be more vulnerable to gas exposure because of higher minute ventilation per kg and failure to evacuate an area promptly when exposed.

Dermal

Skin irritation manifested as reddened skin may occur from exposure to diborane vapors.

Ocular/Ophthalmic

High concentrations of diborane can cause eye irritation, pain, swelling, lacrimation, or photophobia.

Neurologic

Dizziness, headache, weakness, central nervous system depression, and incoordination have been seen following exposure to diborane.

Potential Sequelae

Weakness and fatigue may follow exposure to diborane. Damage to liver and kidneys may occur in some cases during metabolism and excretion.

Chronic Exposure

Chronic exposure to low concentrations of diborane were reported to have caused seizures, convulsions, fatigue, drowsiness, confusion, altered EEG responses, and spasms of the voluntary muscles. Others have reported headache, vertigo, chills, and sometimes fever. Asthmatic bronchitis can also occur.

Chronic exposure may be more serious for children because of their potential for a longer latency period.

Carcinogenicity

Diborane has not been classified for carcinogenic effects.

Reproductive and Developmental Effects

No information is available regarding reproductive or developmental effects of diborane in experimental animals or humans. Diborane is not included in *Reproductive and Developmental Toxicants*, a 1991 report published by the U.S. General Accounting Office (GAO) that lists 30 chemicals of concern because of widely acknowledged reproductive and developmental consequences.

Prehospital Management

- **Rescue personnel are at low risk of secondary contamination from victims who have been exposed to diborane gas. However, rescuers entering areas with potential high concentrations should wear appropriate equipment to avoid self-exposure to diborane. An air concentration of 15 ppm is considered “immediately dangerous to life or health”.**
- **Acute exposure to diborane gas causes chest tightness, coughing, skin, eye and nose irritation, and lacrimation. Respiratory impairment and noncardiogenic pulmonary edema may occur.**
- **There is no specific antidote for diborane poisoning. Treatment is supportive.**

Hot Zone

Rescuers should be trained and appropriately attired before entering the Hot Zone. If the proper equipment is not available, or if rescuers have not been trained in its use, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

Rescuer Protection

Diborane is a severe respiratory-tract and skin irritant.

Respiratory Protection: Positive-pressure, self-contained breathing apparatus (SCBA) is recommended in response situations that involve exposure to potentially unsafe levels of diborane.

Skin Protection: Chemical-protective clothing should be worn because diborane gas can cause skin irritation and burns.

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Apply direct pressure to stop bleeding.

Victim Removal

If victims can walk, lead them out of the Hot Zone to the Decontamination Zone. Victims who are unable to walk may be removed on backboards or gurneys; if these are not available, carefully carry or drag victims to safety.

Consider appropriate management of anxiety in victims with chemically-induced acute disorders, especially children who may suffer separation anxiety if separated from a parent or other adult.

Decontamination Zone

Victims exposed to diborane gas who have no skin or eye irritation do not need decontamination. They may be transferred immediately to the Support Zone. All others require decontamination as described below.

Rescuer Protection

If exposure levels are determined to be safe, decontamination may be conducted by personnel wearing a lower level of protection than that worn in the Hot Zone (described above).

ABC Reminders

Quickly establish a patent airway, ensure adequate respiration and pulse. Stabilize the cervical spine with a collar and a backboard if trauma is suspected. Administer supplemental oxygen as required. Assist ventilation with a bag-valve-mask device if necessary. Apply direct pressure to control bleeding.

Basic Decontamination

Victims who are able may assist with their own decontamination. Remove and double-bag contaminated clothing and personal belongings.

Flush exposed skin and hair with copious amounts of plain water for at least 15 minutes. Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers after decontamination as needed.

Do not irrigate eyes that have sustained frostbite injury. Otherwise, irrigate exposed or irritated eyes with plain water or saline for no less than 30 minutes. Eye irrigation may be carried out simultaneously with other basic care and transport. Remove contact lenses if it can be done without additional trauma to the eye. If pain or injury is evident, continue irrigation while transferring the victim to the support zone.

Consider appropriate management of chemically contaminated children at the exposure site. Provide reassurance to the child during decontamination, especially if separation from a parent occurs.

Transfer to Support Zone

As soon as basic decontamination is complete, move the victim to the Support Zone.

Support Zone

Be certain that victims have been decontaminated properly (see *Decontamination Zone* above). Victims who have undergone decontamination pose no serious risks of secondary contamination to rescuers. In such cases, Support Zone personnel require no specialized protective gear.

<i>ABC Reminders</i>	Quickly establish a patent airway and ensure adequate respiration and pulse. If trauma is suspected, maintain cervical immobilization manually and apply a cervical collar and a backboard when feasible. Administer supplemental oxygen as required and establish intravenous access if necessary. Place on a cardiac monitor. Watch for signs of airway swelling and obstruction such as progressive hoarseness, stridor, or cyanosis.
<i>Additional Decontamination</i>	Continue irrigating exposed skin and eyes, as appropriate.
<i>Advanced Treatment</i>	<p>In cases of respiratory compromise, secure airway and respiration via endotracheal intubation. If not possible, perform cricothyrotomy if equipped and trained to do so.</p> <p>Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol.</p> <p>Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution, repeat every 20 minutes as needed cautioning for myocardial variability.</p> <p>Patients who are comatose, hypotensive, or having seizures or who have cardiac arrhythmias should be treated according to advanced life support (ALS) protocols.</p> <p>If evidence of shock or hypotension is observed, begin fluid administration. For adults with systolic pressure less than 80 mm Hg, bolus perfusion of 1,000 mL/hour intravenous saline or lactated Ringer’s solution may be appropriate. Higher adult systolic pressures may necessitate lower perfusion rates. For children with compromised perfusion administer a 20 mL/kg bolus of normal saline over 10 to 20 minutes, then infuse at 2 to 3 mL/kg/hour.</p> <p>If frostbite is present, treat by rewarming in a water bath at a temperature of 102 to 108 °F (40 to 42 °C) for 20 to 30 minutes and continue until a flush has returned to the affected area.</p>
<i>Transport to Medical Facility</i>	Only decontaminated patients or those not requiring decontamination should be transported to a medical facility. “Body bags” are not recommended.

Report to the base station and the receiving medical facility the condition of the patient, treatment given, and estimated time of arrival at the medical facility.

Multi-Casualty Triage

Consult with the base station physician or the regional poison control center for advice regarding triage of multiple victims.

Patients with evidence of significant exposure (e.g., severe or persistent cough, dyspnea, or chemical burns) should be transported to a medical facility for evaluation. Patients who have minor or transient irritation of the eyes or throat may be discharged from the scene after their names, addresses, and telephone numbers are recorded. They should be advised to seek medical care promptly if symptoms develop or recur (see *Patient Information Sheet* below). The development of serious respiratory symptoms may be delayed for up to 24 hours.

Emergency Department Management

- **Hospital personnel are at minimal risk of secondary contamination from patients who have been exposed to diborane gas. However, hospital personnel in an enclosed area can be secondarily contaminated by vapors off-gassing from heavily contaminated clothing or skin.**
- **Acute exposure to diborane initially causes coughing, eye and nose irritation, lacrimation, and a burning sensation in the chest. Airway constriction and noncardiogenic pulmonary edema may occur.**
- **Diborane irritates the skin and can cause burning pain, inflammation, and blisters. Exposure to liquefied diborane can result in frostbite.**
- **There is no specific antidote for diborane poisoning. Treatment requires supportive care.**

Decontamination Area

Unless previously decontaminated, all patients with skin or eye irritation require decontamination as described below.

Be aware that use of protective equipment by the provider may cause anxiety, particularly in children, resulting in decreased compliance with further management efforts.

ABC Reminders

Evaluate and support airway, breathing, and circulation. In cases of respiratory compromise secure airway and respiration via endotracheal intubation. If not possible, surgically secure an airway.

Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution, repeat every 20 minutes as needed cautioning for myocardial variability.

Patients who are comatose, hypotensive, or having seizures or cardiac arrhythmias should be treated in the conventional manner.

Basic Decontamination

Patients who are able may assist with their own decontamination. Remove and double bag contaminated clothing and personal belongings.

If skin and eye contact with liquified diborane occurred, handle frostbitten with caution. Place frostbitten skin in warm water, about 108 °F (42 °C). If warm water is not available, wrap the affected part gently in blankets. Let the circulation reestablish itself naturally. Encourage the victim to exercise the affected part while it is being warmed.

Flush exposed skin and hair with plain water for no less than 15 minutes. Use caution to avoid hypothermia when decontaminating victims, particularly children or the elderly. Use blankets or warmers after decontamination as needed.

Do not irrigate frostbitten eyes. Otherwise, begin irrigation of exposed eyes. Remove contact lenses if it can be done without additional trauma to the eye. Continue irrigation while transporting the patient to the Critical Care Area.

Critical Care Area

Be certain that appropriate decontamination has been carried out.

ABC Reminders

Evaluate and support airway, breathing, and circulation as in ABC Reminders above under *Decontamination Zone*. Establish intravenous access in seriously ill patients if this has not been done previously. Continuously monitor cardiac rhythm.

Patients who are comatose, hypotensive, or having seizures or cardiac arrhythmias should be treated in the conventional manner.

Inhalation Exposure

Administer supplemental oxygen by mask to patients who have respiratory symptoms. Treat patients who have bronchospasm with an aerosolized bronchodilator such as albuterol.

Consider racemic epinephrine aerosol for children who develop stridor. Dose 0.25–0.75 mL of 2.25% racemic epinephrine solution, repeat every 20 minutes as needed cautioning for myocardial variability.

If pulmonary edema develops, maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed. Prophylactic antibiotic therapy may reduce the chances of respiratory infection.

Skin Exposure

If the skin was in contact with diborane, thermal burns may occur. Treat thermal burns by assuring that affected area is cool by flushing

with cool water, then apply dry sterile dressings. If the patient is burned on the face, neck head, or chest, assume that the airway may also have been burned.

If the liquefied diborane gas contacts the skin, frostbite may result. If a victim has frostbite, treat by rewarming affected areas in a water bath at a temperature of 102 to 108 °F (40 to 42 °C) for 20 to 30 minutes and continue until a flush has returned to the affected area.

Eye Exposure

Diborane-exposed eyes should be irrigated for at least 15 minutes. Test visual acuity and examine the eyes for corneal damage and treat appropriately. Immediately consult an ophthalmologist for patients who have corneal injuries.

Antidotes and Other Treatments

There is no specific antidote for diborane. Treatment is supportive.

Laboratory Tests

The diagnosis of acute diborane toxicity is primarily clinical, based on respiratory difficulties and irritation. However, laboratory testing is useful for monitoring the patient and evaluating complications. Routine laboratory studies for all exposed patients include CBC, glucose, and electrolyte determinations. Patients who have respiratory complaints may require pulse oximetry (or ABG measurements) and chest radiography. Massive inhalation may be complicated by hyperchloremic metabolic acidosis; in addition to electrolytes, monitor blood pH.

Disposition and Follow-up

Consider hospitalizing patients who have a suspected significant exposure or have eye burns or serious skin burns.

Delayed Effects

Symptomatic patients complaining of persistent shortness of breath, severe cough, or chest tightness should be admitted to the hospital and observed until symptom-free. Pulmonary injury may progress for several hours.

Patient Release

Asymptomatic patients and those who experienced only minor sensations of burning of the nose, throat, eyes, and respiratory tract (with perhaps a slight cough) may be released. In most cases, these patients will be free of symptoms in an hour or less. They should be advised to seek medical care promptly if symptoms develop or recur (see the *Diborane—Patient Information Sheet* below).

Follow-up

Obtain the name of the patient's primary care physician so that the hospital can send a copy of the ED visit to the patient's doctor.

Follow up is recommended for all hospitalized patients because long-term respiratory problems can result. Respiratory monitoring is recommended until the patient is symptom-free. In addition, long-term follow-up should seek neuropsychiatric abnormality. Kidney and liver tests are also indicated.

Patients who have skin or corneal injury should be re-examined within 24 hours. Anyone who had significant dermal exposure should be followed for several months.

Reporting

If a work-related incident has occurred, you may be legally required to file a report; contact your state or local health department.

Other persons may still be at risk in the setting where this incident occurred. If the incident occurred in the workplace, discussing it with company personnel may prevent future incidents. If a public health risk exists, notify your state or local health department or other responsible public agency. When appropriate, inform patients that they may request an evaluation of their workplace from OSHA or NIOSH. See Appendix III for a list of agencies that may be of assistance.

Diborane

Patient Information Sheet

This handout provides information and follow-up instructions for persons who have been exposed to diborane.

What is diborane?

Diborane is a colorless gas with a repulsive, sweet odor. It is used in rocket propellants and as reducing agent, as a rubber vulcanizer, as a catalyst for olefin polymerization, as a flame-speed accelerator, and as a doping agent. Because diborane is a gas at ambient temperature, the most likely exposure routes are inhalation and dermal.

What immediate health effects can be caused by exposure to diborane?

Even small exposures to diborane may cause immediate irritation of the eyes, nose, and throat, and shortness of breath, as well as coughing, wheezing, shortness of breath, and tearing of the eyes. Some of these signs and symptoms may develop several hours after exposure occurred. Exposure to diborane can also cause dizziness, headache, drowsiness, and lack of coordination. Breathing large amounts of diborane may cause the lining of the throat and lungs to swell, making breathing difficult. Generally, the more serious the exposure, the more severe the symptoms.

Can diborane poisoning be treated?

There is no antidote for diborane, but its effects can be treated and most exposed persons get well. Persons who have experienced serious symptoms may need to be hospitalized.

Are any future health effects likely to occur?

A single small exposure from which a person recovers quickly is not likely to cause delayed or long-term effects. After a serious exposure, symptoms may worsen for several hours and respiratory and neurologic alterations may persist for long time.

What tests can be done if a person has been exposed to diborane?

Specific tests for the presence of diborane in blood or urine generally are not useful to the doctor. If a severe exposure has occurred, blood and urine analyses and other tests may show whether the upper respiratory airways and lungs or brain have been injured. Testing is not needed in every case.

Where can more information about diborane be found?

More information about diborane can be obtained from your regional poison control center, your state, county, or local health department; the Agency for Toxic Substances and Disease Registry (ATSDR); your doctor; or a clinic in your area that specializes in occupational and environmental health. If the exposure happened at work, you may wish to discuss it with your employer, the Occupational Safety and Health Administration (OSHA), or the National Institute for Occupational Safety and Health (NIOSH). Ask the person who gave you this form for help in locating these telephone numbers.

Follow-up Instructions

Keep this page and take it with you to your next appointment. Follow *only* the instructions checked below.

Call your doctor or the Emergency Department if you develop any unusual signs or symptoms within the next 24 hours, especially:

- coughing or wheezing
- difficulty breathing, shortness of breath, or chest pain
- increased pain or a discharge from injured eyes
- increased redness or pain or a pus-like discharge in the area of a skin burn

No follow-up appointment is necessary unless you develop any of the symptoms listed above.

Call for an appointment with Dr. _____ in the practice of _____.

When you call for your appointment, please say that you were treated in the Emergency Department at _____ Hospital by _____ and were advised to be seen again in _____ days.

Return to the Emergency Department/ _____ Clinic on (date) _____ at _____ AM/PM for a follow-up examination.

Do not perform vigorous physical activities for 1 to 2 days.

You may resume everyday activities including driving and operating machinery.

Do not return to work for _____ days.

You may return to work on a limited basis. See instructions below.

Avoid exposure to cigarette smoke for 72 hours; smoke may worsen the condition of your lungs.

Avoid drinking alcoholic beverages for at least 24 hours; alcohol may worsen injury to your stomach or have other effects.

Avoid taking the following medications: _____

You may continue taking the following medication(s) that your doctor(s) prescribed for you: _____

Other instructions: _____

• Provide the Emergency Department with the name and the number of your primary care physician so that the ED can send him or her a record of your emergency department visit.

• You or your physician can get more information on the chemical by contacting: _____ or _____, or by checking out the following Internet Web sites: _____;

Signature of patient _____ Date _____

Signature of physician _____ Date _____